Offline jet calibration experience at Dzero

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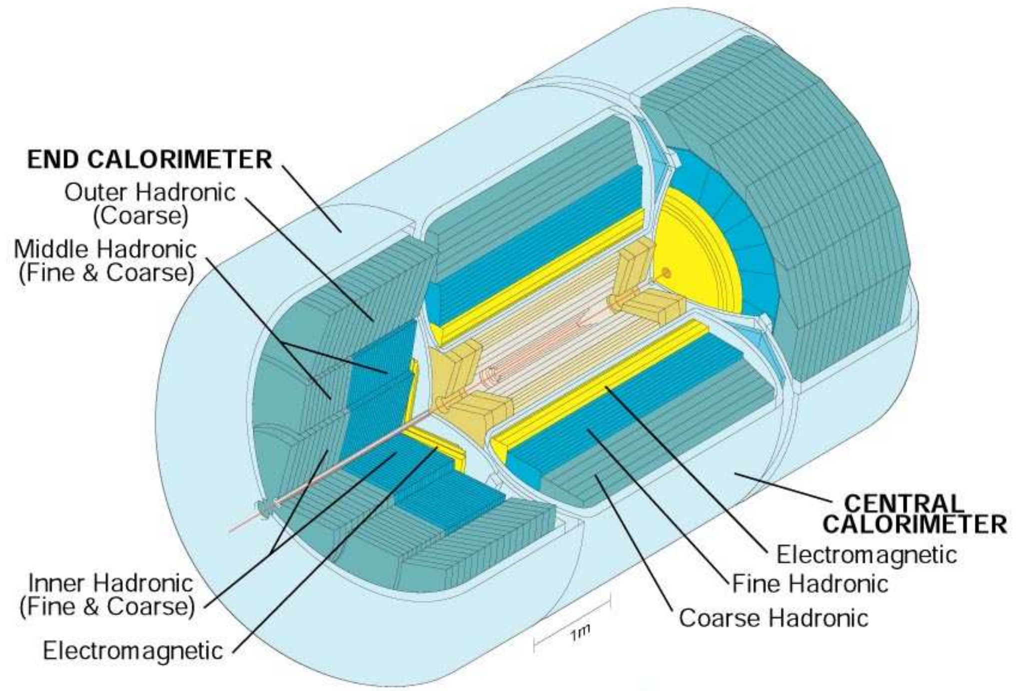
Dzero Calorimeters

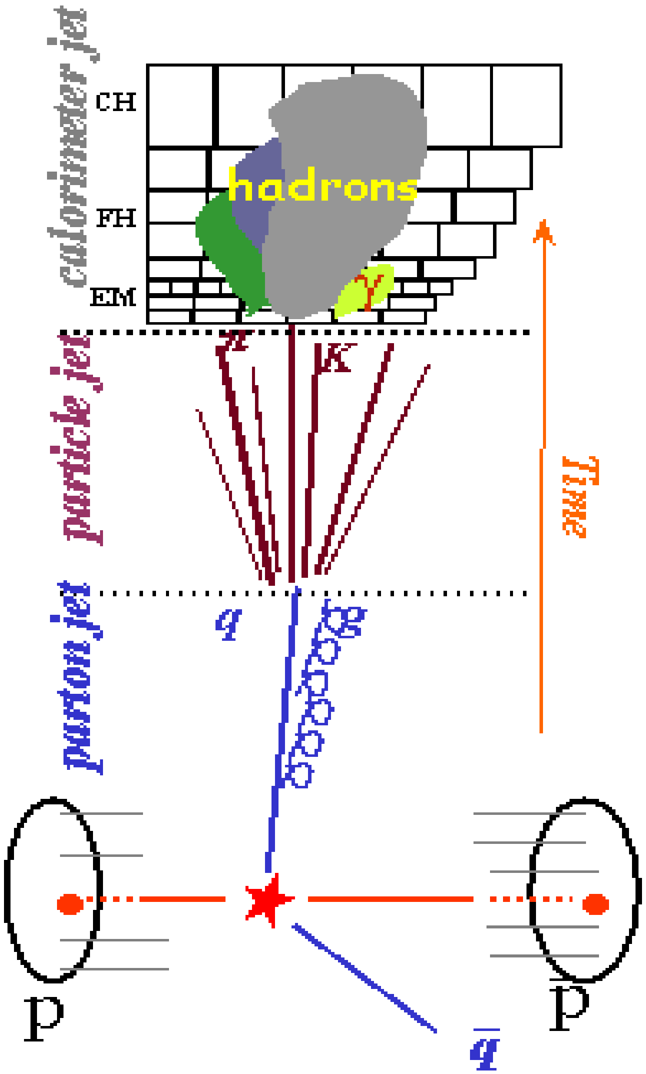
- Uranium-Liquid Argon Calorimeters, Central (CC) and Endcap (EC) cryostats
  - compensating with

    e/π<1.05 for E>30 GeV
  - uniform, radiation hard, dense, compact
  - hermetic with |η|<4.2
  - 7-9 interaction lengths
- Region between CC and EC instrumented by Inter Cryostat Detector (ICD) and Massless Gaps (MG):
  - ICD consists of an array of scintillator tiles
  - MG – separate single cell structures



50K cells, 5K towers
granularity of 0.1x0.1 in η x φ
(0.05x0.05 for 3rd EM layer)

Jet Energy Scale



For a cone jet true particle level jet energy is obtained from measured on using the following formula:

$$E^{ptcl}_{jet} = \frac{E^{meas}_{jet} - O}{R_{jet}\, S_{cone}}$$

Where,

O is an energy offset from electronics and Uranium noise, energy pile-up, additional ppbar inetraction and underlying events.

Rjet is calorimeter response

Scone is the fraction of the jet calorimeter shower contained in the algorithm cone

For KT jet there is no **Scone** contribution

Calorimeter jet → particle jet

Offset measurement

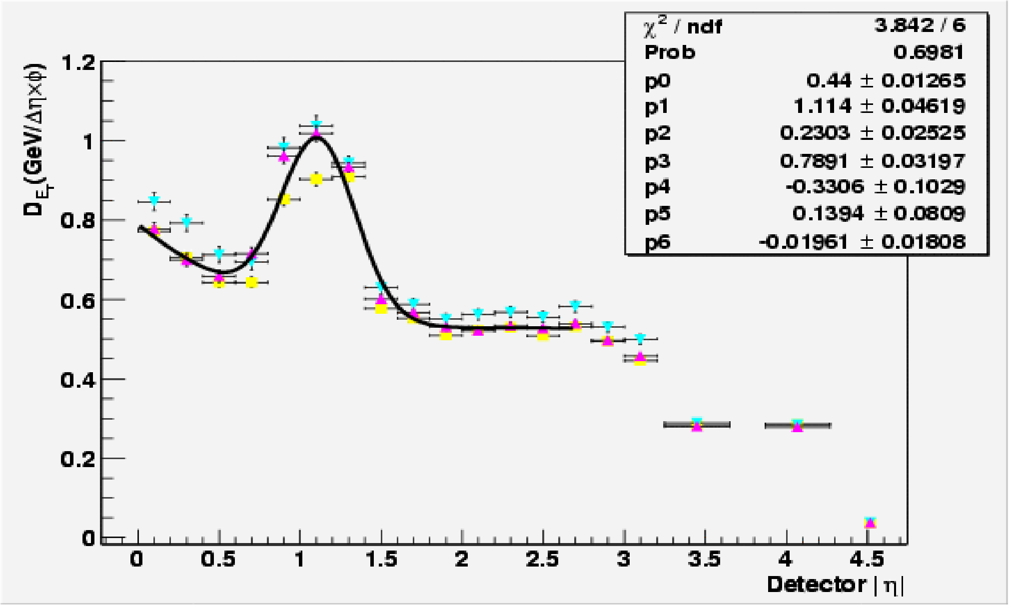
- Offset correction is measured as average (over azimuthal angle) transverse energy densities in calorimeter eta rings:

$$\mathcal{D}_{E_T} = \frac{\sum_{All\phi} E_T(\eta)}{2\pi \times \omega_\eta \times N_{events}}$$

- For collider data we use Minimum Bias (an interaction has occurred) runs taken at various luminosities and Zero Bias (random crossing) trigger runs taken at low luminosity ➔ it is possible to separate *underling event* contribution (luminosity independent part) from *noise* + *pile-up* +*multiple ppbar* contribution (luminosity dependent part)

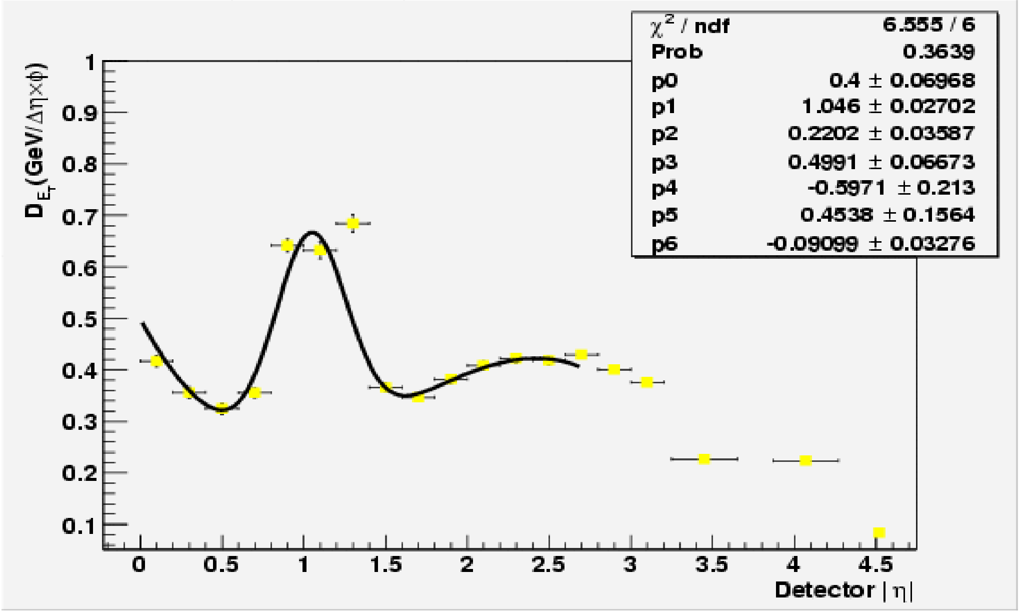
- MC offset derived using Pythia minbias events (*underlying event contribution*) superimposed with <mb>=0.8 (*multiple ppbar interaction contribution*)

Offset measurement



Run II data
(PRELIMINARY)

- L=11.5E30/cm^2/s
- L=19.5E30/cm^2/s
- L=32.5E30/cm^2/s



Run II MC
(PRELIMINARY)

Response correction

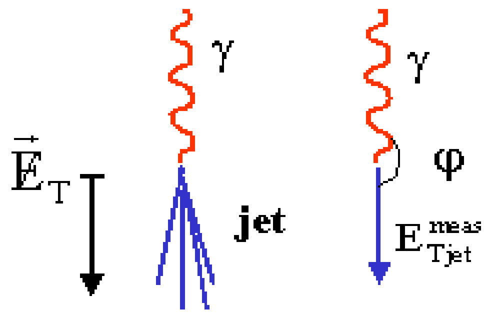
Calorimeter response is typically < 1:
- **h/e <1**
- **Uninstrumented regions**
- **Module-to-module fluctuations**

MissingET Projection Fraction (MPF) method

Based on energy balance in the transverse plane

γ+ jets collider data

γ Calibrated using $Z \rightarrow e^+ e^-$ data



$$\boxed{R_{jet} = 1 + \frac{\vec{E}_T \cdot \hat{n}_\gamma}{E_{T\gamma}}}$$

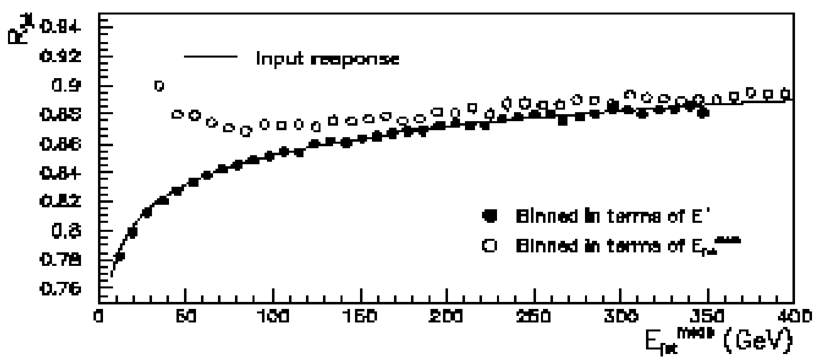
R_{jet} vs E_{jet}^{meas}

$E = E_T \cosh(\eta)$

E': jet energy estimator

$$\boxed{E' = E_{T\gamma} \cosh(\eta_{jet})}$$

Map $E' \longrightarrow E_{jet}^{meas}$

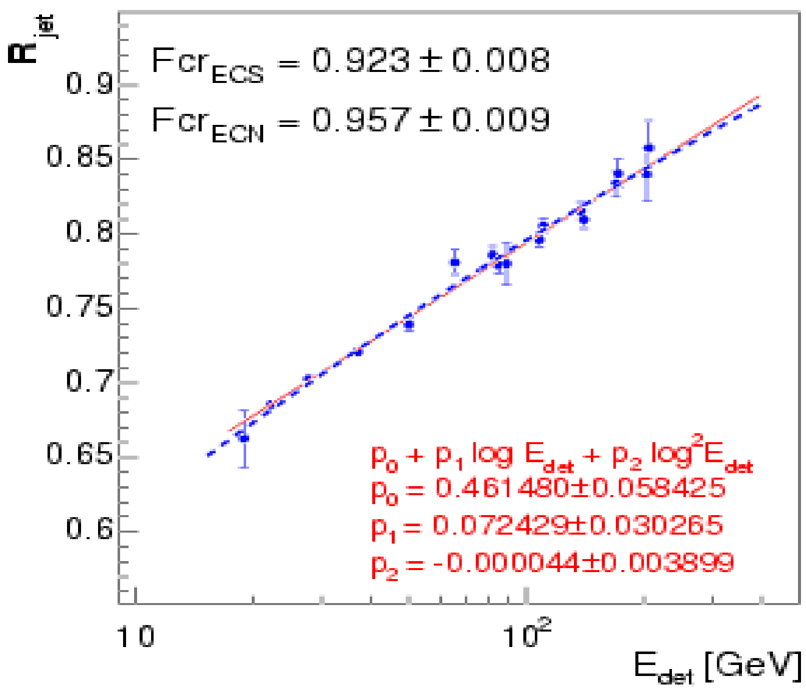


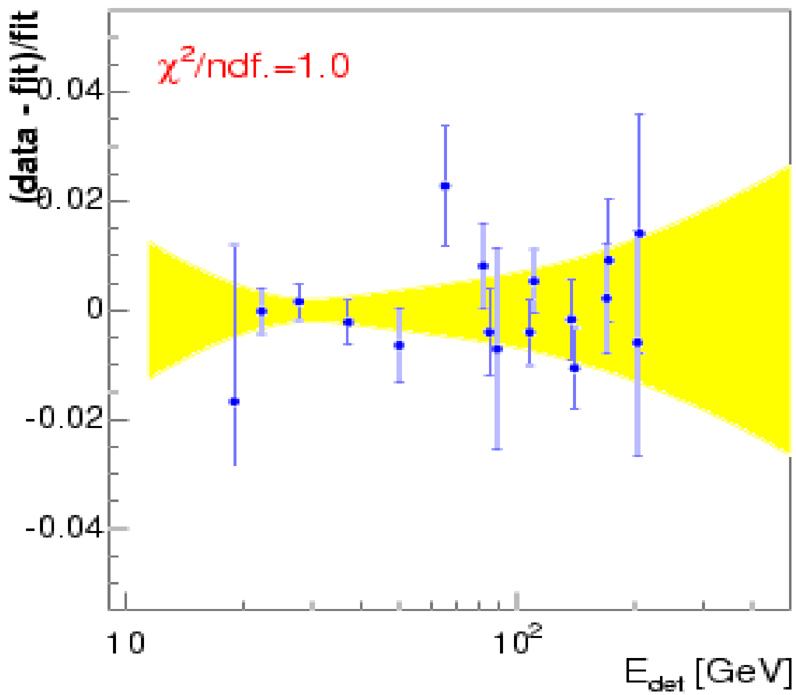
Monte Carlo simulation

Response -- Dzero Run II data (PRELIMINARY)

Nonlinearities for low momenta particles ⟶ $R_\pi \sim \ln(P)$

$$\boxed{R_{jet} = a + b\ \ln(P_{jet}) + c\ \ln^2(P_{jet})}$$





Response measurement

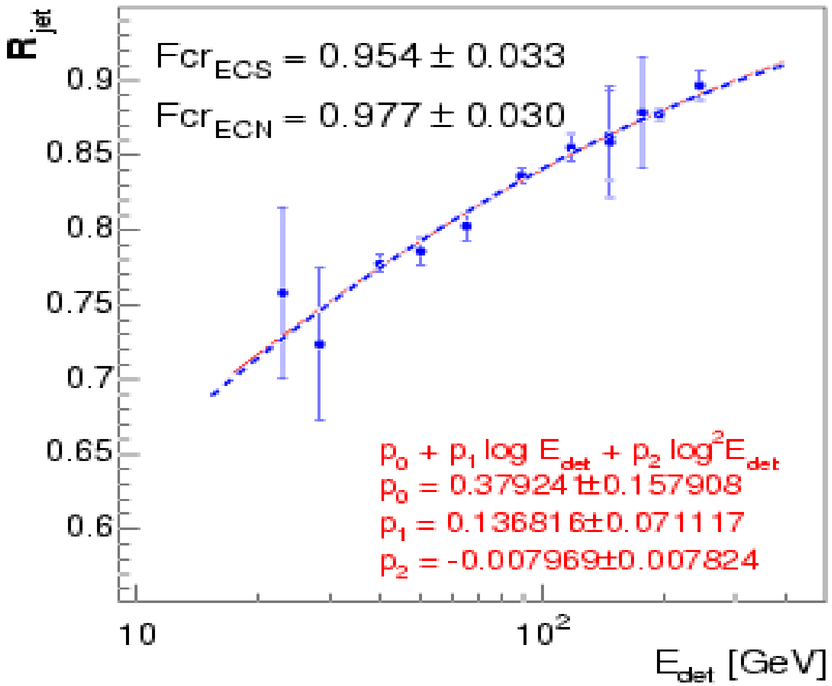
- Response is measured separately in three cryostats: CC, ECS, ECN

- Response meaurements from the three cryostats are combined to cover wide range of jet energies

- CC jets cover energy range below about 100 GeV forward jets (Endcaps) allow access to high energies above > 100 GeV

- Global fit allows EC points to float through a normalization parameter Fcry=Rjet(EC)/Rjet(CC)

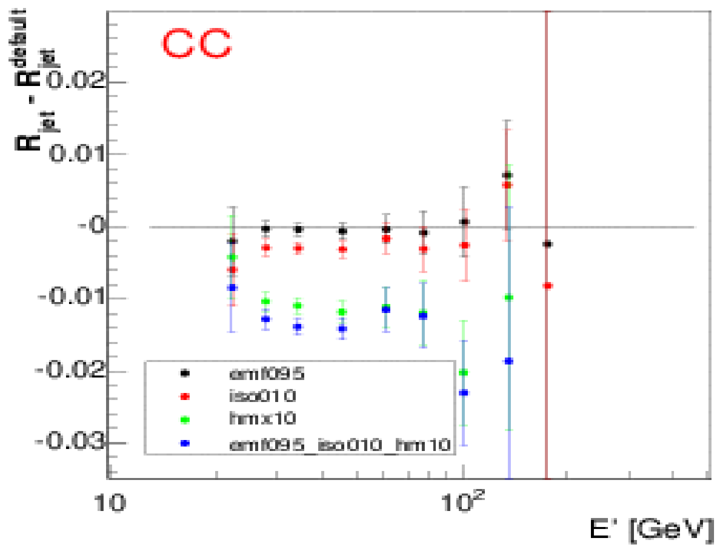
Run II MC (PRELIMINARY)

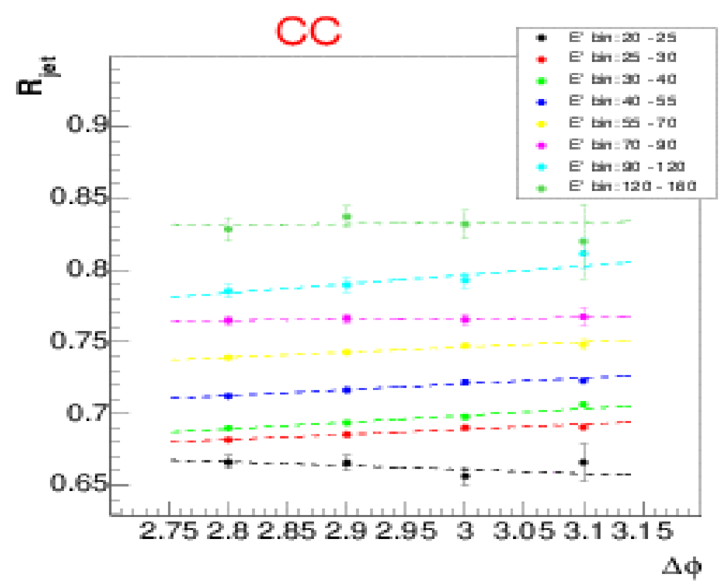


Statistical error ~1-2% in the energy range of 20-200 GeV (data, MC)

Response: systematic uncertainties

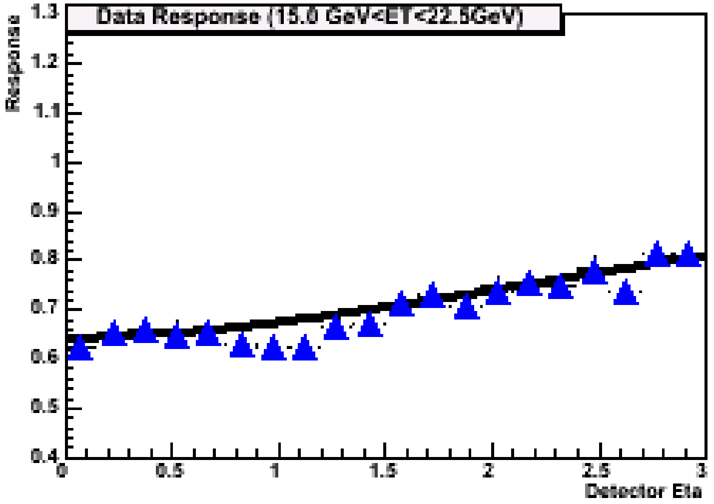
- Various systematic uncertainties:
  - Level of QCD background in photon+jets calibration sample. Studied through variation of photon ID cuts: ~ 1-2%
  - Topology (photon/jet back-to-backness) systematics ~1-4%
  - Event primary vertex selection <1%
  - MET systematics ~ 0.5%
- At low energies, E<20 GeV main systematic due to low ET bias – effect of 8 GeV offline reconstruction cut on jet ET, steeply falling spectrum and jet resolution
- At high energies E>250 GeV large systematic error from response extrapolation

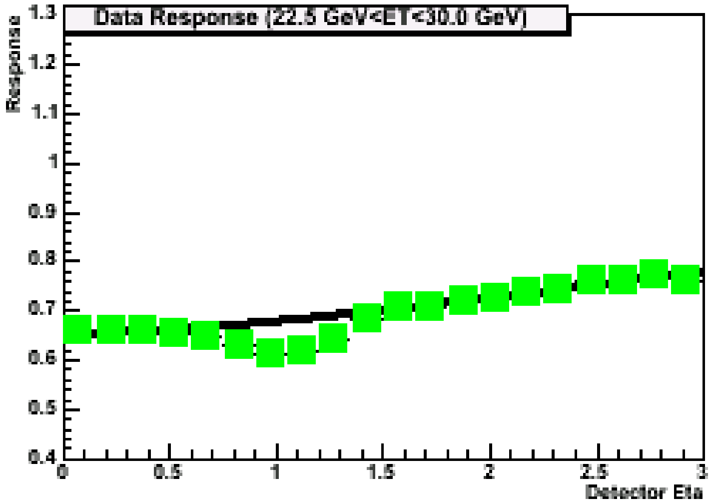


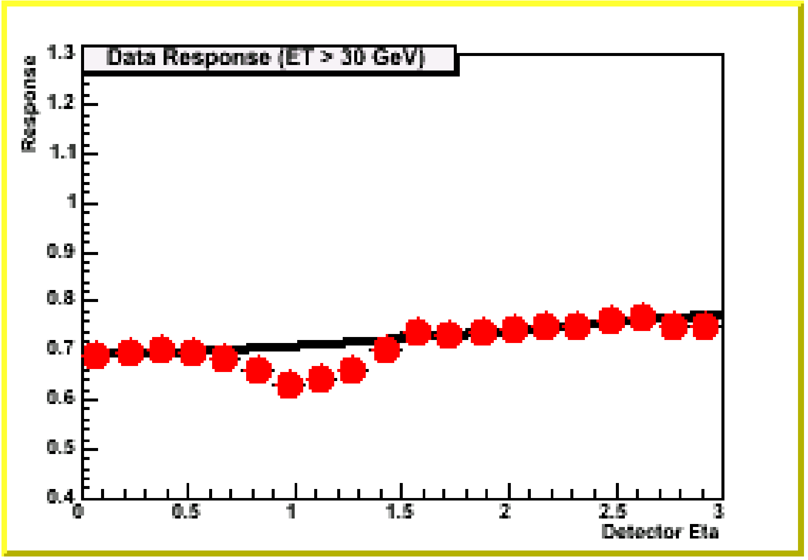


Response non-uniformity: correction for Inter Cryostat Region (ICR)

- Measure response as a function of jet detector η: non-uniformity of the detector in the ICR region
- Use $a+b\log(\eta)$ fits to take out energy dependence

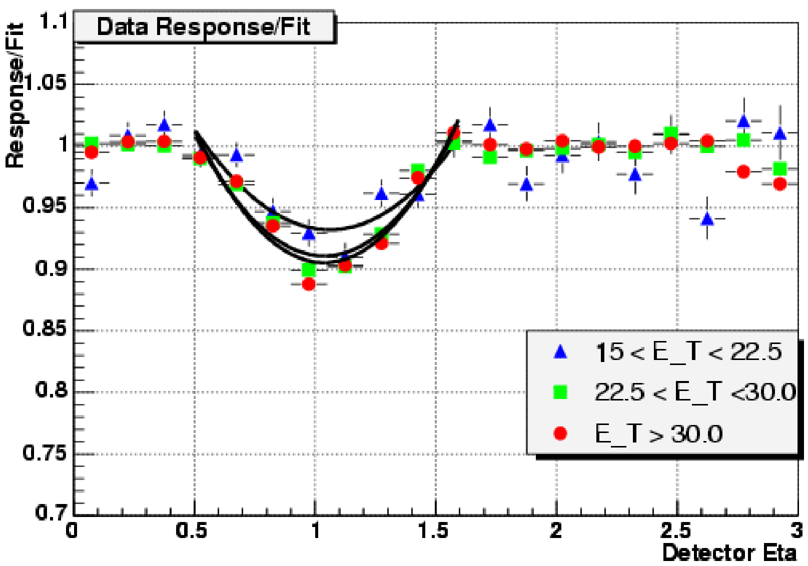




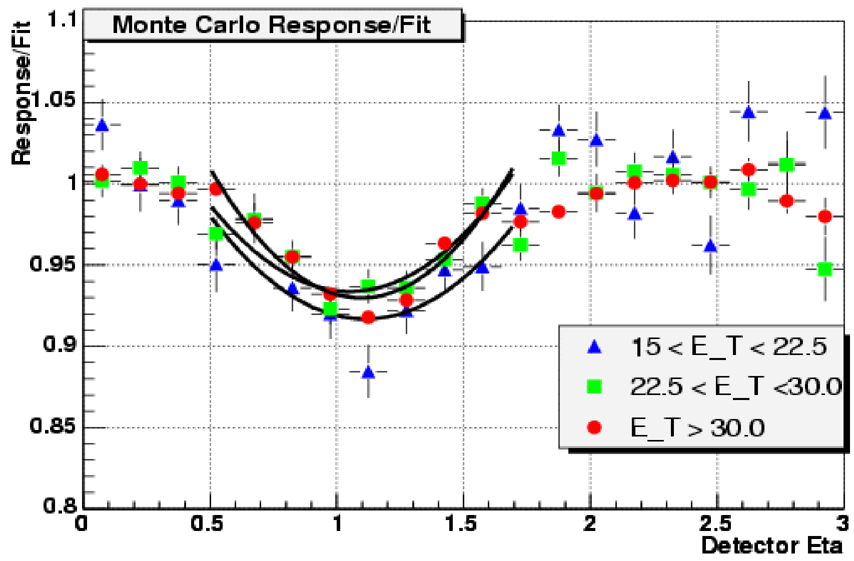


ICR corrections

Run ELIMINARY)



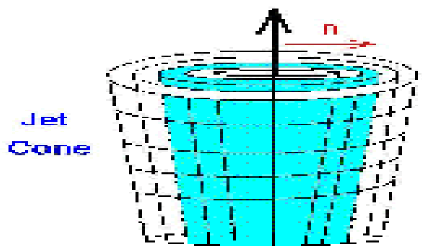
Run II MC (PRELIMINARY)



- About 7-10% (6-8%) drop in response for data (MC) at $\eta \sim 1.1 - 1.2$
- Apply additional correction to jet in the η region of 0.5 - 1.6
- Correction weekly depends on jet ET

Showering correction

- Some particles produced inside the jet cone deposit fraction of their energy outside the cone when shower develops in the calorimeter, and vica versa → Scone is the fraction of the jet energy showered inside the cone in the calorimeter
- Method: measure ET densities in rings around the jet axis in back-to-back dijet and photon+jet data → total out-of-cone (OOC) showering



$$r = \sqrt{(\eta - \eta_o)^2 + (\phi - \phi_o)^2}$$

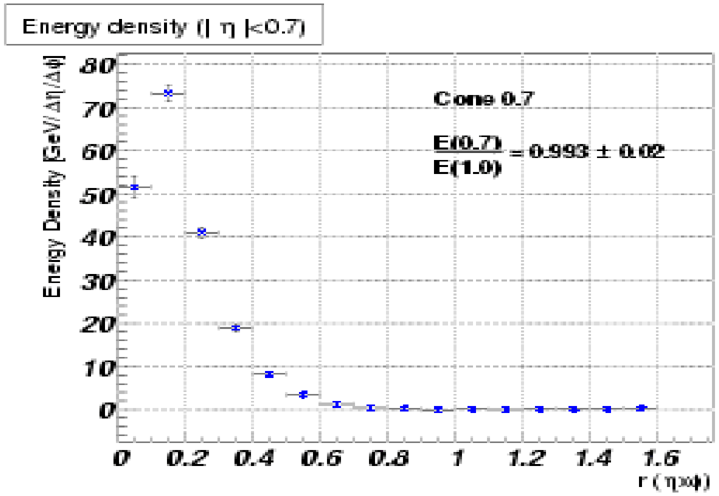
- Separate detector OOC showering from physics OOC:

Fsho = Ftot – Fphy + 1, where Fphy is measured using MC particle jets

Rcone = 1/Fsho

Showering correction (cont.)

$$S_{cone} = \frac{E_{cone}}{E_{jetlimit}}$$

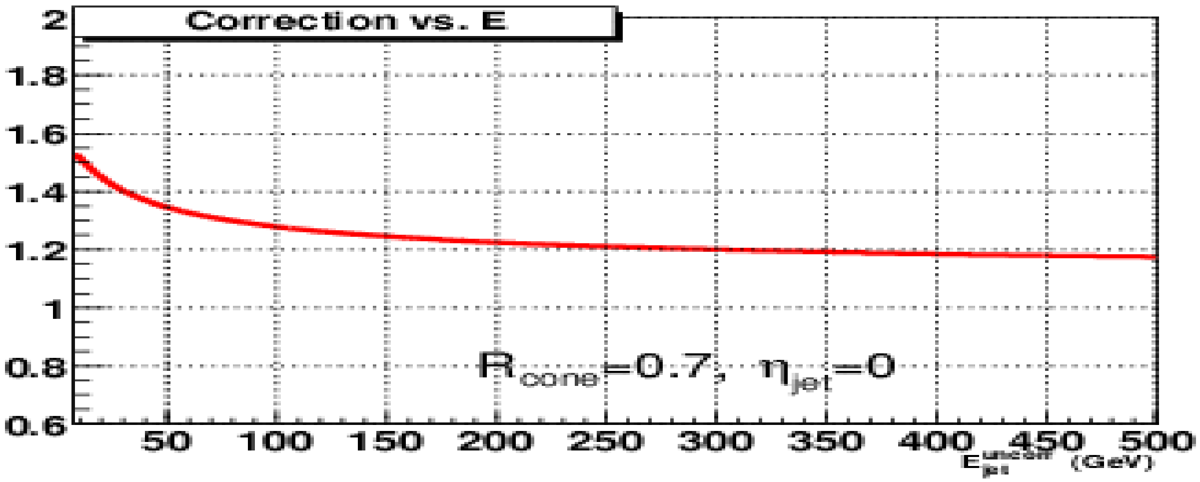


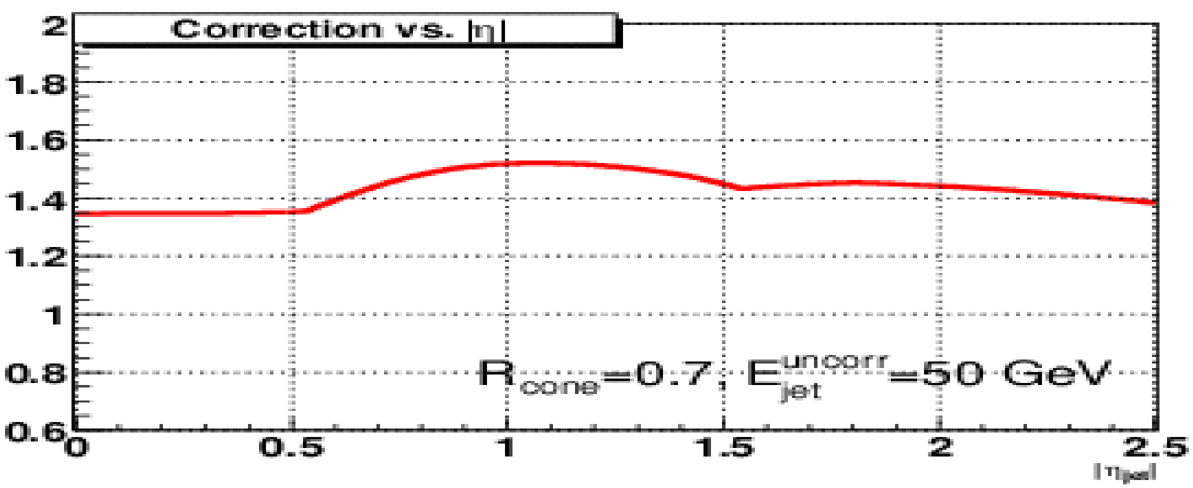
	$r = 0.7$	$r = 0.5$
Central	0.99	0.92
ICR	0.96	0.89
Forward	0.94	0.85

- Scone is smaller in the forward η region due to the shrinkage of the physical space with η
- Large systematic uncertainty, ~10% at large η, and small ET.
- Systematics can be reduced by 'direct' derivation of Scone, i.e. by comparing the particle energy produced inside (outside) the cone with the energy deposited outside (inside) the cone at the calorimeter level.

Overall JES correction for data

Dzero Run II data (PRELIMINARY)

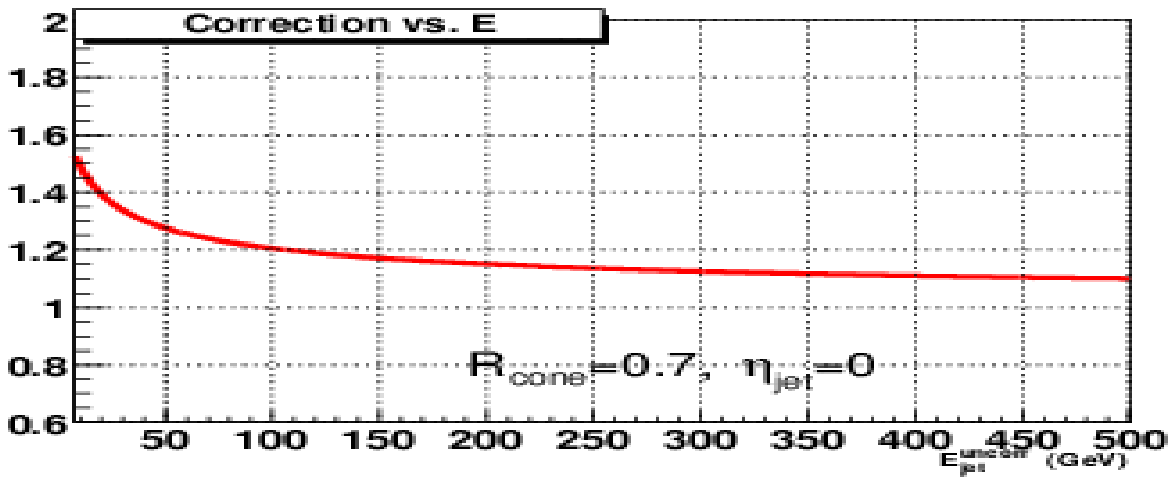


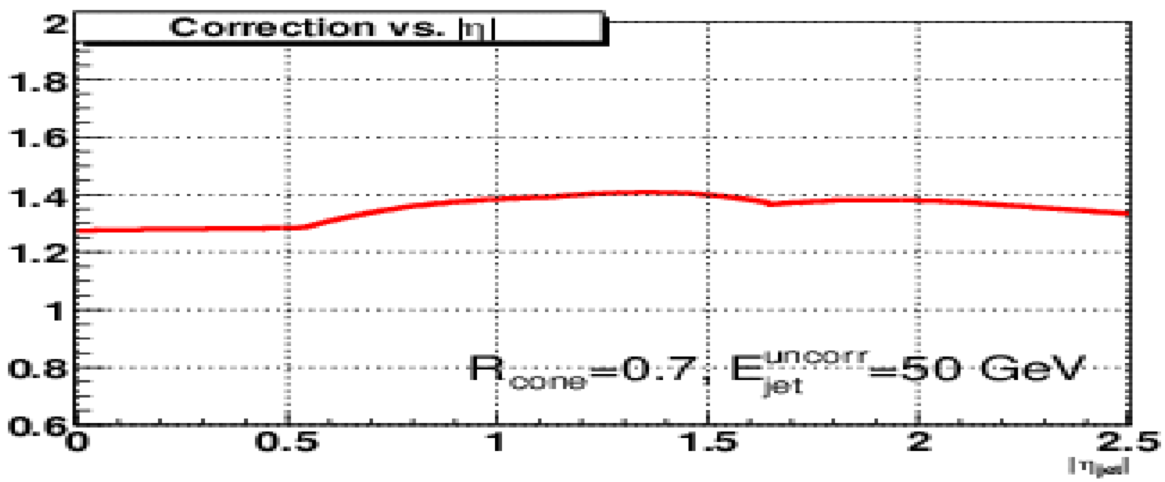


For central jets with E=50 (300) GeV correction size is ~1.35 (1.2)

Overall JES correction for MC

Dzero Run II MC (PRELIMINARY)





For central jets with E=50 GeV (300) GeV correction size is ~1.27 (1.15)

Outlook

- In Run I Dzero has achieved Jet Energy Scale error of 2-3% in the energy range of 10-500 GeV
- In Run II this can be decreased down to 1-2% making use of larger photon+jets sample, better tracking and magnetic field ➔ in-situ calibration using charged particle momentum information
- The b-jet energy calibration is under study